

Article

Blockchain-Based Business Process Management (BPM) for Finance: The Case of Credit and Claim Requests

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Abstract: Because of the competitive economy, organizations today seek to rationalize, innovate, and adapt to changing environments and circumstances as part of business process improvement efforts. The strength of blockchain technology lies in its usage as an apt technology to enhance the efficiency and effectiveness of business processes; furthermore, it prevents the use of erroneous or obsolete data and allows sharing of confidential data securely. The use of superior technology in the execution and automation of business processes brings opportunities to rethink the specific process itself as well. Business processes modeling and verification are essential to control and assure organizational evolution, therefore, the aim of this paper is three-fold: firstly, to provide business process management patterns in finance, based on blockchain, specifically for the loan-application process in the banking industry and claim process in the insurance industry that could be used and customized by companies; secondly, to critically analyze challenges and opportunities from the introduction of such approach for companies, and thirdly, to outline how companies can implement the loan business process as a web service. Partner companies (a bank and an insurance company) formulated the potential requirements for M2P along with the application of blockchain technology. An experimental design framework was established that gave the necessary services to model the requirements, check the models, and operationalize the models. The applied research methodologies are as follows: design science research paradigm and software case study, model-to-programming (M2P) of business processes, and utilization of patterns of workflow and blockchain.

Keywords: blockchain; business process; business process modelling (BPM); finance; loan; technology management; service-oriented computing



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1. Introduction

BPM (business process management and modeling) as a discipline tries to increase the performance of companies by studying business processes, and possibilities for business process optimizations [1]. In the course of the development of the research branch, it has matured as an academic and professional discipline. The contemporary BPM is a widely adopted and deployed scientific field on both the academic and practitioner sides. BPM tries to respond to and address pressing issues in all sectors of business IT (information technology) and to foster value creation for companies.

However, with the rise of the large number of opportunities connected with digitization, the established BPM methods are not fully capitalizing on the latest opportunities that are offered by contemporary technology. For instance, blockchain technology has gained widespread traction, yet its use for business process aims is in its infancy [2].

The use of blockchain has the power to revolutionize the interoperability among multi-parties in cross-organization business workflows. It buttresses systems that automatically gather, analyze and process data. Reasonable decentralization is key to promoting trust

among different and not directly connected departments of a company. Hence, these are strong motivations that push companies to develop and implement new open business processes that are transparent to everyone, including the final user.

A blockchain is a ledger of all transactions which are stored in a distributed database. One or a single transaction can constitute a block. Each time, a transaction is made, it is linked to a chain, with every block containing a hash of the previous blocks in order of sequence. The fact that the data are stored in a distributed way makes it impossible to change its data. Changing the data would require that one changes the data in each block in each of the distributed databases at the same time. Thus, this solution makes such scenarios impossible within the currently available technologies.

Some benefits of using blockchain are [3]:

- Blockchain records are secure and reliable,
- Blockchain are immutable, therefore one block/record cannot be changed,
- There is no need to validate the data by a third party.

Blockchain technology can become an essential component of BPM solutions employed by companies, to mitigate the problems of security, openness, and cost-effectiveness.

Some examples of current applications of blockchain in the financial industry include the Corda platform [4]. This platform is a collaborative effort of 40 banks to redesign the current settlement process by enabling financial agreements to be stored on the blockchain and thereby help improve reconciliation processes to become more optimal. The Australian stock exchange implements a system based on a blockchain ledger [5]. In the UK welfare program, the welfare payment process uses blockchain technology [6]. In Sweden, land records are put on the blockchain so that banks (for purposes of delivering loans and mortgages), government agencies, buyers, and sellers can track changes in real time [7]. More recently, machine learning and AI have been applied to business process prediction. Such models are on the rise, and therefore could be used by companies, still, this is not the case, as in our view what is missing is the interpretability part, and what it means to provide meaningful business process interpretations. BPM literature has already explored how machine learning can be used to predict and gain insights into processes. Little attention has been paid still in the literature on how to explain this model to business users, which are not data scientists and are only experts in their fields. Thereby, they may also not understand the explanations provided to them. Therefore, we believe the BPM community should build on the AI interpretability community to provide such meaningful interpretations.

Some information is usually lost when preparing the data for predictive model analysis. Thus, a second and more ambitious aim is to bring additional process awareness regarding business models; that is, to take advantage of the knowledge of the business process definitions and augment interpretability with knowledge obtained from the business model definition.

The community needs to develop metrics on the quality of explanations, and already available business process datasets can be used for this aim. Model accuracy, as applied as a metric in other fields, may not be relevant in this area of study. This may be a growing area of interest for companies as well due to the high level of applicability.

The first approach to use blockchain in finance has proliferated as mentioned previously, yet it has not yet fully explored the domain of what it means to use blockchain for business processes improvements, thereby, this article brings a new view on this issue, and especially focuses on the loan application and insurance claim process. It aims to provide a multidimensional analysis of the use of blockchain for BPM in finance and focuses on scenarios of exploitation and acquainting this technology with the domain of BPM and the improvement of existing processes.

In this paper, our focus is on the financial industry, and financial business processes, and we focus on the loan application business process. In the process of a loan application, the outcome is whether the loan is approved or not. The key process decision is shown in Figure 1.

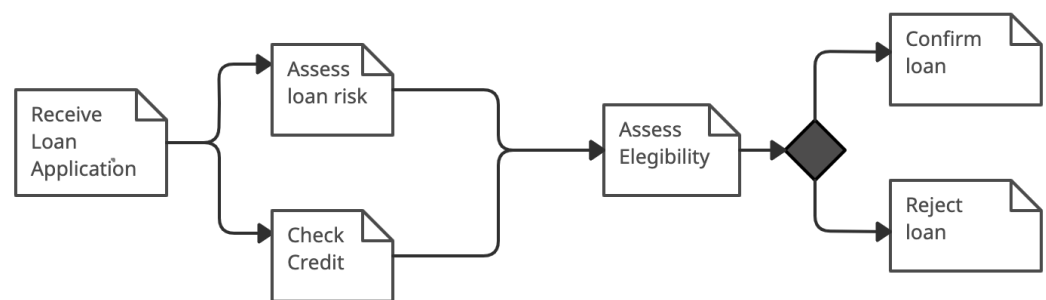


Figure 1. Loan application process.

The loan business process usually consists of five activities or work steps as follows: submitting a loan application, assessment of the loan application (through loan risk assessment and estimation of property value), and either approval of the loan application or rejection of the loan application.

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If the process exploits blockchain technology, the different information can be automatically checked and verified. Firstly, then the whole process would become more transparent for all; secondly, it would increase the speed of response of the bank, moreover, it would minimize the cost of such operations for the bank.

In this scenario, the use of blockchain would provide better, faster, and less erroneous data checks. It yields speedier and more reliable processing of loan claims, and automation of policy enforcement. In such cases in particular, the chain of decision activities is clear enough, so there is no need for a final checkup by a clerk. Therefore, in the loan scenario, blockchain would help resolve some current market challenges, such as:

- All the parties involved in the loan application, revision, and approval will have a single view of the data in a distributed ledger and blockchain platform;
- Manual processes can be automated, via checks of the data coded into blocks of blockchain and the use of “smart contracts”;
- The whole process is immutable, and everyone can see changes in status in the application; there is clear visibility of ownership, which makes it easy also to be a subject of audits, and the whole process is transparent.

With the explosion of data available on social media and the IoT (the Internet of things), there is also the ability to objectively assess loan requests. This situation may give a helping hand in the assessment of the loan application, whether they are correct or not. Provided data that can be trusted and protected from fraud, the business process regarding loan applications can be significantly improved and made much faster. Moreover, given the transparency of the entire process, it is likely that customer satisfaction will be improved too.

In addition, we see how blockchain, when completed with business process knowledge, can improve the quality of service. This is a fruitful research area, one where we can only begin an investigation about it.

From what is said above, we can see that blockchain can solve many of the urgent problems of the financial industry. The benefits of the blockchain need to be exploited and explored, blockchain validation will reinstate trust among different parties in these processes.

The rest of the paper is organized as follows: Section 2 presents background work and related literature on the use of blockchain in Business Process Management and Modeling and looks out for the formal and technological development of borderline areas. Section 4 presents the loan business process and its patterns of the workflow, moreover, the possible inclusion of blockchain patterns in the application, the section investigates advantages and challenges for financial companies, as well as how the loan business process can be

implemented as a web service. Furthermore, this section analyses a business process in a similar financial services technologies domain but in a different field, namely in insurance and InSurTech. Section 5 showcases the results of the research work that were described in the paper. Section 6 summarizes the content of the paper and discusses future challenges. Finally, the paper concludes with Section 7.

2. Blockchain-Related Literature Overview

The use of blockchain technology is rapidly expanding [8]. Many researchers are looking into it from various angles. It is a technique for storing and transmitting information in the form of a chain of blocks in a decentralized, secure, and transparent manner. Many well-known companies, such as Google, Microsoft, and Blackrock, utilize blockchain.

Various research works and literature reviews about blockchain have been recently published [9,10]. Blockchain is widely used in enabling decentralized cryptocurrency platforms and financial technology [11] to reduce the risk and eliminate much of the processing and transaction fees. It is used in (a) international payments, (b) peer-to-peer transactions, (c) fighting bank fraud (security) [12], (d) insurance and transaction automation, (cryptocurrencies) [13,14], (e) decentralized finance (DeFi) and smart contracts [15], and (f) health services and sharing medical data (privacy) [16]. It helps in gaining more security, accuracy, and in lowering costs. Blockchain is often used to solve more complex problems. Ref. [17] shows the importance of using blockchain in distributed applications (dApps). It helps provide trustworthiness in a trustless environment, improving data reconciliation, and optimizing resource distribution.

The blockchain has the ability to bring business process management back to life. Blockchain can make processes involving numerous parties in systems transparent by employing its ability to audit distributed ledger technology and smart contracts, as well as obeying some specific regulatory regulations. It can connect data, circulate documents, and track multiple stages of a transaction. The authors of the paper [18] presented a blockchain-based business process management system (Caterpillar) which uses smart contracts to encode the status of business process instances and conduct workflow routing. Another paper, Ref. [19], shows how blockchain technology may help firms reduce transaction costs, improve collaborative business processes, and reinforce trustworthiness and transparency while also assisting with data consistency and security governance and reconciliation.

Wattana et al. [20] looked at an automated BPM system for selecting and composing services in an open business environment in another study. They investigated and proposed blockchain technology (BCT) as a means of transferring and verifying the trustworthiness of enterprises and partners. They created a BPM framework to show how blockchain technology may be used to assist in quick, accurate, and cost-effective evaluation and the transfer of service quality in workflow composition and management. Various studies have been conducted on the use of blockchain technology in BPM. The study by [21] discusses the theories, problems, and important success aspects of using blockchain to handle business processes. For the interoperation of business processes in smart supply chains and business process monitoring, blockchain technologies are used in Refs. [22,23].

The survey paper by Rafael et al. [24] presented a business process view integration of the past, present, and future applications of blockchain. The work by Pierre [19] also presented the benefits, costs, and barriers of improving BPM with blockchain. Blockchain solutions have been used and combined with M2P solutions [25–28]. In [29], we used blockchain as a UML profile for business processes and workflows in finance. Blockchain technology is quickly growing [8]. Many researchers are studying it from several sides. It is a technology for storing and transmitting information, in a decentralized, secure, and transparent way, in the form of a chain of blocks. Numerous large and well-known companies use blockchain, such as Google, Microsoft, Blackrock, etc. In addition, other review articles link blockchain and BPM. These two papers [30,31], in particular, discuss the challenges, opportunities, and methodological support of blockchains for business process management in the classical BPM lifecycle; in the phases of identification, discovery,

analysis, redesign, implementation, execution, monitoring, and adaptation, and also from the side of strategy, governance, information technology, people, and culture.

2.1. The Most Recent Developments in Blockchain Technologies on the Application in Insurance, Auditing, and Banking

The major application area of blockchain technology is the various business processes of enterprises that include the internal processes and tasks of companies. The review [32] identifies and discusses four main themes related to the impact of blockchain technology on accounting record-keeping. These themes include the adoption of an event-based approach to accounting, the implementation of real-time accounting processes, the concept of triple-entry accounting, and the potential for continuous auditing. External and internal auditing and accounting are important business processes that should rely on regulatory compliance and conformance with business rules. There are business processes that realize the commercial and communication channels, e.g., supply chain management. The authors of Ref. [33] examine the potential benefits and challenges of implementing blockchain technology in the fashion and textile supply chain. They provide a comprehensive analysis of the technology's potential in improving traceability, transparency, and product authenticity within the industry. The review discusses the opportunities that blockchain technology presents in the fashion and textile supply chain and provides insights into the potential challenges of adopting this technology. The further digital transformation of the banking sector impacts the business processes of the banking industry. Ref. [34] discusses the sector of digital banking, which has made great strides in providing financial transactions that are user-friendly, efficient, and speedy. It has also played a crucial role in enabling cashless transactions during the economic downturn triggered by the COVID-19 pandemic. This research examines the obstacles, technology, and potential areas of research in digital banking considering blockchain technology and artificial intelligence that includes data science, big data analytics, and deep learning. The authors of [35] present an overview of the potential applications of blockchain and IoT in Industry 4.0 and Society 5.0. By leveraging smart contracts, blockchain networks can ensure the validity of transactions and prevent fraudulent activities. Moreover, the automation capabilities of IoT can enable real-time data processing, which can enhance the efficiency of various applications. However, the integration of these technologies also presents challenges, such as addressing the technical limitations of IoT devices and managing the complexity of blockchain mining. Additionally, businesses, including insurers, must carefully consider the benefits and drawbacks of using blockchain technology.

2.2. Related Works

Our research aims at a combined application of the M2P paradigm and the most recent blockchain technologies. The M2P modeling paradigm provides a theoretical framework for building up a pipeline from the actual modeling methods to the current operationalization or interpretative systems [36]. The design models can be checked by formal methods, namely Alloy and YAWL [26,37–40]. Service innovation is a crucial approach in the recent enterprise environment to realize digital transformation [41]. The authors of Ref. [42] showcase how to innovate the insurance claim process with the assistance of blockchain technologies in the case of the healthcare industry. The paper meticulously analyzes the protocols of security and related communications through formal descriptions and their implementations through smart contracts. A high-level process structure of the claim process is also outlined. The authors of [42,43] describe how smart contracts can be used for the realization of insurance contracts. The paper presents the blocks in the blockchain that implement the contracts and make them executable if the pre-conditions are met. Both mentioned papers concentrate on the application of smart contracts for insurance policies and the exploitation of an executable nature. The data and information flow are represented in a simple format focusing on the business-to-customer interaction. The complex internal activities and tasks are not dealt with, since the fulfillment of the

contractual and compliance requirements by the executable smart contracts is the focus in addition to the security aspects. Our paper does not intend to carry out a systematic, quantitative literature review; however, a qualitative literature review is provided in Table 1 and shows the most recent and relevant works.

Table 1. Summary and assessment of relevant papers of the related works.

Title of Publication	Author(s)	Year	Summary of the Publication	Assessment
A comprehensive survey on blockchain-based healthcare industry: applications and challenges [44]	S. A. Bennacer, K. Sabiri, A. Aaroud, K. Akodadi, and B. Cherradi	2023	The paper presents a comprehensive survey on the applications and challenges of blockchain technology in the healthcare industry. The authors use the PRISMA approach and review 56 research publications in high-ranking scientific journals from 2016 to 2022. The paper discusses how blockchain technology can potentially address a variety of challenges faced by healthcare systems, such as data management, security, data sharing, and patient privacy. The study identifies the potential of blockchain technology to assist patients and healthcare providers in diagnosis and data processing.	The paper provides a valuable overview of the current state of blockchain technology in the healthcare industry. The authors use a systematic approach to review a large number of research publications, highlighting the potential applications of blockchain technology in healthcare. However, the study does not provide a detailed analysis of the challenges and limitations of implementing blockchain technology in the healthcare industry, which could have added further value to the paper.
Accounting and auditing with blockchain technology and artificial Intelligence: A literature review [45]	H. Han, R. K. Shiwakoti, R. Jarvis, C. Mordi, and D. Botchie	2023	The paper surveys the literature on the impact of blockchain technology on accounting and auditing, with a specific focus on the integration of AI-enabled auditing. The authors explore how blockchain technology can enhance transparency and trust in accounting practices, and how professionals can leverage blockchain data to improve decision-making. They identify four themes that have emerged from the literature, namely the event approach to accounting, real-time accounting, triple-entry accounting, and continuous auditing. The study also discusses the challenges associated with adopting blockchain.	The paper offers a comprehensive review of the literature on the integration of blockchain and AI in accounting and auditing and provides valuable insights into the potential benefits and challenges of this approach. The study is well-structured and organized, with a clear focus on the research questions and themes. The authors also provide a thorough analysis of the findings, linking them to agency theory and stakeholder theory to advance understanding in the field. The study's limitations are not explicitly discussed, which could limit the generalizability of the findings. However, overall, this paper provides a valuable contribution to the literature on blockchain technology's potential impact on accounting and auditing.
Blockchain—Internet of Things Applications: Opportunities and Challenges for Industry 4.0 and Society 5.0 [35]	A. K. Tyagi, S. Dananjayan, D. Agarwal, and H. F. T. Ahmed	2023	The paper discusses the potential of blockchain technology and Internet of Things (IoT) integration for Industry 4.0 and Society 5.0. It highlights the security and transparency features of blockchain technology and how it can be used to build trust in different industries such as banking, insurance, logistics, and transportation. The paper also emphasizes the real-time applications of blockchain technology and IoT integration. However, the paper also acknowledges the challenges and open issues in the integration of these technologies and suggests future research opportunities for expanding the knowledge base.	The paper provides a concise overview of the potential of blockchain technology and IoT integration in Industry 4.0 and Society 5.0. The authors have given relevant examples to support their claims and discussed the challenges and open issues that need to be addressed in the future. However, the paper could have delved deeper into the technical aspects of how blockchain and IoT integration can work together and the potential benefits and drawbacks of such integration.

Table 1. Cont.

Title of Publication	Author(s)	Year	Summary of the Publication	Assessment
Exploring the potential of blockchain technology within the fashion and textile supply chain with a focus on traceability, transparency, and product authenticity: A systematic review [33]	A. Badhwar, S. Islam, and C. S. L. Tan	2023	The paper provides a systematic review of the potential of blockchain technology in the fashion and textile industry's supply chain for improving traceability, transparency, and product authenticity. The authors have scrutinized a significant number of research papers and non-scholarly resources to highlight the opportunities and challenges of adopting blockchain technology in this industry. The selected research papers include empirical analysis, argumentative, case studies, opinion articles, review articles, short reports, and book chapters. The study concludes that blockchain technology has immense potential to improve the fashion and textile industry's supply chain, but challenges such as scalability, interoperability, and standardization need to be addressed to fully realize its benefits.	Overall, the paper provides a thorough and insightful review of the potential of blockchain technology in the fashion and textile industry's supply chain. The authors have done an excellent job of synthesizing the existing research and identifying the gaps and challenges in the literature. However, the study could have been strengthened by providing more specific examples of blockchain applications in the fashion and textile industry and analyzing their effectiveness in improving traceability, transparency, and product authenticity.
Secured Insurance Framework Using Blockchain and Smart Contract [43]	A. Hassan, Md. I. Ali, R. Ahammed, M. M. Khan, N. Alsufyani, and A. Alsufyani,	2021	The paper presents a framework that uses blockchain and smart contracts to create a secured insurance process. Traditional insurance policy settlements are manual, time-consuming, and prone to errors. The authors suggest that implementing blockchain and smart contracts in the insurance process can provide security, transparency, and authenticity. The framework proposed in the paper uses smart contracts that are stored on the blockchain, and the conditions are immutable. The blockchain network uses the proof of authority (PoA) consensus algorithm to validate transactions.	The paper provides a practical and effective solution to the problems in traditional insurance policy settlement. The framework proposed by the authors can eliminate the chances of fraud claims by the insured and hidden conditions from the insurer. The use of blockchain and smart contracts can make the insurance process more efficient, transparent, and secure. The authors have provided a detailed description of the implementation of the framework, and the use of the Solidity programming language and the PoA consensus algorithm makes the framework more reliable. Overall, the paper provides valuable insight into how blockchain and smart contracts can transform the insurance industry.
A Traceable Online Insurance Claims System Based on Blockchain and Smart Contract Technology [42]	C.-L. Chen, Y.-Y. Deng, W.-J. Tsaur, C.-T. Li, C.-C. Lee, and C.-M. Wu	2021	The current medical insurance claims process is inefficient and involves a complex set of services. Patients have to apply for a diagnosis certificate and receipt from the hospital, send the relevant application documents to the insurance company, and then wait for the company to verify the information before receiving compensation. To solve this problem, the authors propose using blockchain and smart contract technology to create a traceable online insurance claims system. They argue that this technology can effectively open up information channels, promote industry integration, enhance information acquisition, improve supervision, solve risk control and anti-money laundering problems, and provide security requirements.	The paper presents an interesting application of blockchain and smart contract technology in the insurance industry, specifically in the medical insurance claims process. The authors identify some inefficiencies and complexities of the current process and argue that blockchain technology can help solve these problems. However, the paper does not provide a detailed explanation of how exactly the proposed system will work. There are also no empirical results to demonstrate the effectiveness of the proposed system. Nonetheless, the proposed system is a promising area of research and could potentially bring about significant improvements in the efficiency and security of the medical insurance claims process.

Table 1. Cont.

Title of Publication	Author(s)	Year	Summary of the Publication	Assessment
Blockchain for Business Applications: A Systematic Literature Review [46]	I. Konstantinidis, G. Siaminos, C. Timplalexis, P. Zervas, V. Peristeras, and S. Decker	2018	This paper presents a systematic literature review on the current state of blockchain technology adoption in both public and private sectors for various business applications. While the primary focus of blockchain has been on financial services, the study highlights the potentially disruptive effects of the technology in other areas. Overall, the study provides insights into the potential of blockchain technology for business applications and calls for further investigation and development in this field.	The paper provides a valuable overview of the current state of blockchain technology adoption in various business sectors. However, the study does not provide a detailed analysis of the specific business applications of blockchain or the challenges faced by organizations implementing this technology. Additionally, the paper does not offer a comprehensive analysis of the existing literature on the topic, limiting the generalizability of the findings. Nonetheless, the study provides a useful starting point for researchers and practitioners interested in exploring the potential of blockchain technology for business applications.

3. Research Methodology

We applied the design science research paradigm and software case study research method in the research of model-to-programming (M2P) of business processes and utilization of patterns of workflow and blockchain [47,48]. These two methods are used together to design, develop, and evaluate software systems. We used the design science research paradigm to design and implement a new software system for modeling business processes, checking the models by relational logic, and operationalizing the models by M2P [36,37]. Then we used the software case study research method to evaluate the system in terms of its usability, functionality, and effectiveness. The findings of the case study can then be used to improve the design and implementation of the software system, leading to a more effective solution. The business processes were represented by the UML activity diagram. The reason for this is that it is syntactically and semantically simpler than BPMN2.0 and the stakeholders can understand the results more easily so the researchers can carry out the assessment of the results according to the software case study [49,50]. The workflow and blockchain patterns were used for business process transformation and improvement [51,52].

4. Loan Business Process

4.1. Loan Process Business Process Pattern with Blockchain

First, we present the current “AS-IS” implementation traditionally seen in financial institutions (Figure 2), after which we also present the “TO-BE” design of the process as discussed in the rest of the paper (Figure 3).

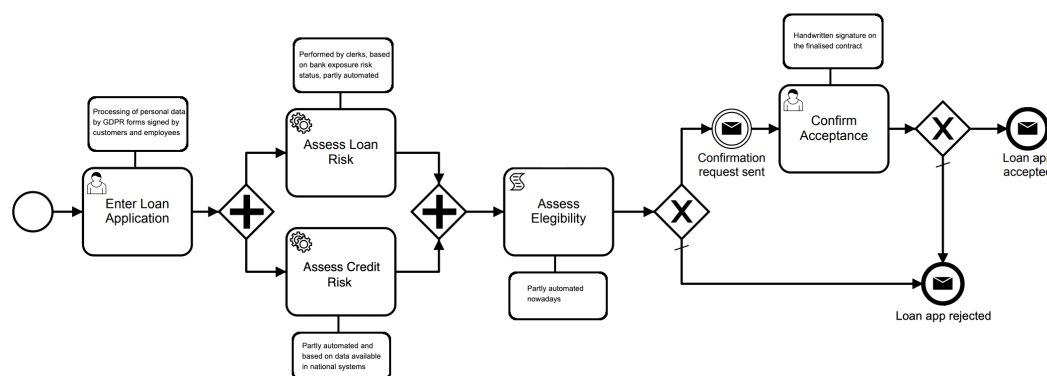


Figure 2. AS-IS loan application business process.

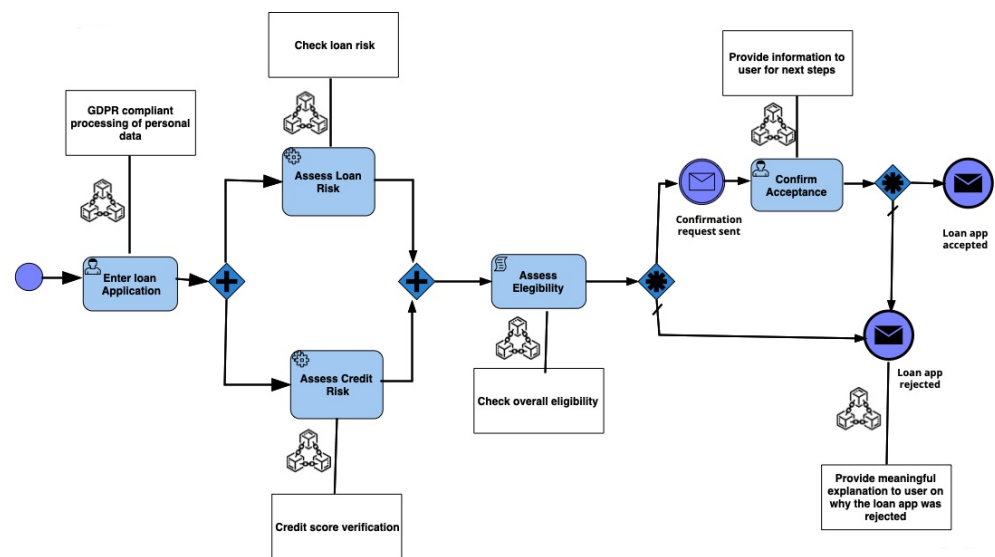


Figure 3. TO-BE loan application process where the different steps of the workflow are performed on the blockchain.

The *MIT Business Process Handbook* contains a comprehensive collection of business process patterns that could be customized for our purposes [53]. We adapted the original patterns to represent the loan application pattern, and Table 2 and Figure 4 show the loan business process where we included blockchain technology in the pattern.

Table 2. Loan application pattern.

Loan Application Pattern	
Description	<ul style="list-style-type: none"> • The process pattern represents the tasks from the beginning of the loan application to the acceptance or rejection; • The verification starts after receiving the loan request (verification of the applicant’s details, residential address, bank statements, income, etc.); • The request is transferred to the responsible person; • The step of verification includes authentication, confirmation, and validation of all data that are given by the applicant; • The result of the verification stage could be acceptance or rejection.
Goal	To describe a sequence of tasks in a model that depicts the approval or rejection of the loan request.
Problem	This pattern obliges the verification and approval that ought to be done at the beginning, and during the execution of the process when different personal and confidential data is used; proper security systems ought to be applied (e.g., blockchain) subsequently.

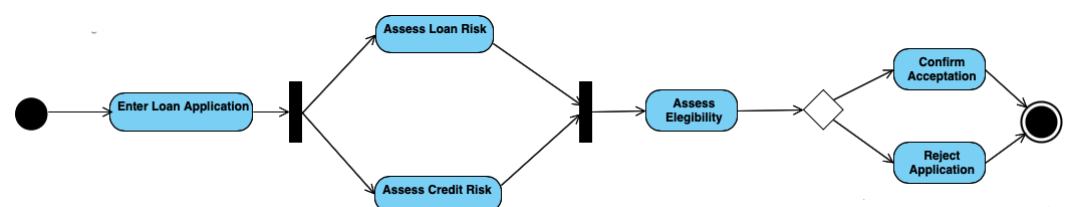


Figure 4. Loan application “UML Activity diagram”.

The patterns provided in the book are a set of patterns that a digitally transformed enterprise can use for its business process management. There is a comprehensive categorization of business processes in the banking industry that we will take into account in future research [54,55]. However, they are to be complemented by modern security mechanisms to safeguard the integrity, consistency, and trustworthiness of the business processes. Therefore, we inserted the components of blockchain technology into the patterns, and the patterns can be used during business process realization.

The workflow remains the same in both the “AS-IS” and “TO-BE” loan application processes; however, the business process is improved on time, quality, costs, and flexibility factors in the “TO-BE” version. This is due to the fact that we replace, for instance, the GDPR-compliant processing of private data from paper-based to a blockchain-based solution. We use a permissioned enterprise blockchain that supports GDPR in such a way that there is only a hash of private data stored on the blockchain, whereas the actual data is stored in a private database, thus improving the process on time and cost factors. In addition, calculations and checks are most often performed partly manually and are again put on the blockchain, which improves the flexibility and quality of the business process.

Our analysis and simulation of the TO-BE process are much superior in all the key factors that are influenced by the restructuring of the business process: time, quality, costs, and flexibility.

Each step is stored on the blockchain, and the data needed for the execution of each step is verified and automatically checked upon reliable sources from the company. Different levels of confidentiality are defined for different types of data (for processing data in compliance with GDPR), and the different steps are checked automatically. For instance, checking a credit score is based on other data in possession of the company or other financial companies; checking loan risk is based on the history of the user and the overall eligibility in terms of the conditions of the loan satisfying national or other bank regulation. In the end, information regarding the loan outcome is presented to the loan requestor; also presented may be the next steps to take, in case the loan application has been successful, or a meaningful explanation of why the loan was rejected, in cases where the application is not successful (Figure 2).

The BPM life-cycle literature also defines different phases in managing business processes [56], and tells us how an organization can arrive to an improved business process by following six steps: (i) process identification, that is, setting high-level understanding and assessment of the current state of the process, (ii) process discovery, overall organization portfolio of processes and description of each state of each process, (iii) process analysis, tools, and methods used to analyze and determine weaknesses, (iv) process re-design refers to a phase in which the process is re-designed and the involved actors and roles are critically examined if they can be improved, (v) process implementation, use of new technologies, and implementation techniques to improve process execution, and (vi) process monitoring and controlling: the use of different methods and tools to control the execution of a business process.

In this paper, we do not try to re-design the loan application process, but we try to improve its process implementation with the use of superior technology that makes the process more transparent for the managers and employees at different levels on one hand, and from another hand makes it more understandable for the final user. The previously mentioned phases are rarely executed together, yet they are useful to clarify how BPM-related activities can contribute to the improvement of the business process at hand. We use the framework introduced in Ref. [56] to describe how and what it will mean to blockchain-based business process management for loan application business processes for banks and financial institutions.

- **Introduction and story of the business process case:** the loan application is one of the most common operations banks perform. Banks face a demand for credit, so the primary role of their staff is to screen applicants and monitor outstanding loans. Loan officers perform an important strategic task in the process of a loan application, by evaluating loan risk and checking the previous credit scores of the applicant.
- **Current situation faced:** current loan applications are lengthy in time and require specialized personnel with lots of experience to process them. The current loan processes foresee the evaluation of eligibility by loan officers, and this analysis may often not be visible to other managers and departments within the bank. In addition, customers often complain about the lack of clarity and transparency in the processes of the bank, and the lack of a clear understanding of the steps and checks that the bank

performs regarding their requests. It may not be understandable to the end customers why their loan was rejected. If this is the case, it is necessary to know what the reason was (due to low credit score in risk analysis, or does the risk seem too big for the bank to undertake?). Lastly, data must be treated in accordance with GDPR [57].

- **Action taken:** the underlying technological solution, such as the one that we propose in this paper, based on blockchain technology, can improve the execution of the process and make the process more transparent.
- **Lessons learned:** based on our previous works [58,59], we understood that financial companies are slow adaptors of new technologies. Technical teams, working on loan technology solutions, would need to perform mapping between their current solutions and the solution as described in our article, then critically analyze the feasibility of the transformation for their company from different points of view, namely technical and managerial viewpoints.
- It gives companies the ability to assemble teams around such developments freely, which can include “smart contracts”, and allow the company to automatize business processes.
- Identities are created for past and current events to be recognized, e.g., new employees of companies can also see past actions on blockchain and act in line with previous decisions made, helping pass knowledge in the company.
- Institutional memory: there are indelible extracts of all transactions and past actions of the company.

4.2. Insurance Claim Process

Blockchain technology has the ability to transform the insurance industry. One of the key benefits of blockchain technology is its ability to improve efficiency by automating various insurance activities including policy management, underwriting, and claims processing. With the use of blockchain, these processes may be automated, lowering administrative expenses and accelerating the claims process. Furthermore, the usage of blockchain can improve transparency and data exchange among insurers, consumers, and other stakeholders. This has the potential to minimize fraud and increase confidence in insurance. Additionally, blockchain technology provides a high degree of protection for insurance data, which helps us avoid data breaches and other security concerns. The deployment of blockchain technology can result in cost savings for insurance businesses. Finally, increased consumer satisfaction may be accomplished through speedier claims processing, more policies, and better transparency. These advantages underline the significance of integrating blockchain technology in insurance in order to remain competitive and provide better experiences for clients.

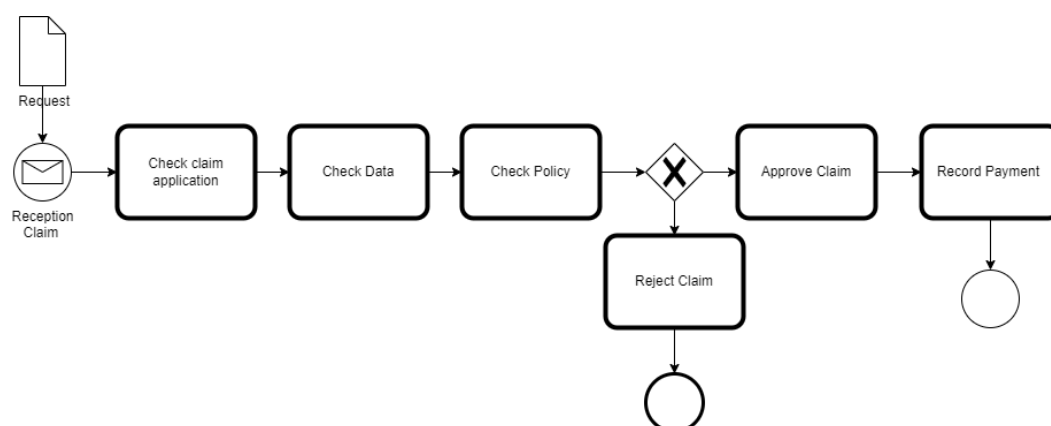
The insurance industry is always growing. In the field of new insurance products, client demands have increased. Customers have become more demanding and have learned to expect the highest service quality.

The use of blockchain technology in the insurance business provides an opportunity for positive change and progress.

Insurance may be performed through blockchain accounts, offering additional automation and tamper-proof audit trails. Notably, the cheap cost of smart contracts and related transactions means that many goods may be made more competitive for penetration into underdeveloped markets in the developing globe. First, we demonstrate the standard “AS-IS” (Figure 5, Table 3) implementation in an insurance company, followed by the “TO-BE” process.

Table 3. Insurance claim pattern.

Insurance Claim Pattern	
Description	<ul style="list-style-type: none"> • The process pattern represents the tasks from the beginning of an insurance claim to the acceptance or rejection; • A document is created that confirms that the claim request is received. • The verification starts after receiving the claim request verification and recording of the customer details, policy identifier, customer identifier, perhaps the case identifier, etc.; • The request is transferred to the responsible person who is selected; • Then, the clerk selects the specific insurance holder, address, and the relevant data for the specific insurance case whose information matches with the given data; • A document that confirms the insurance claim application is created and transferred to the customer through a communication channel that is determined by the given data by the customer by the clerk. • The result of the verification stage could be acceptance or rejection. • The clerk responsible for the decision according to the claim assesses the application. • Then, based on calculations and evaluations, the clerk decides about the rejection or acceptance, and in the case of acceptance of the settlement, the amount of payment.
Goal	To describe a sequence of tasks in a model that depicts the approval or rejection of the claim request.
Problem	This pattern obliges the verification and approval which ought to be carried out at the beginning, and during the execution of the process when different personal and confidential data is used; proper security systems ought to be applied (e.g., blockchain) subsequently. The compliance of the verification process and claim assessment should be maintained and tracked to make it transparent. The documents and the results of the procedural steps should be stored in an immutable data architecture.

**Figure 5.** AS-IS insurance business process.

The AS-IS Claim process typically involves a lengthy application process, which requires significant documentation and verification. The process can be time-consuming and complex, with multiple intermediaries involved in the process. However, the TO-BE claim process implemented with blockchain technology can streamline the process and provide several benefits. The application of blockchain technology in the TO-BE loan process can provide a decentralized network in which all parties have real-time access to the same data. This can decrease the need for middlemen while also speeding up the claim verification and approval procedure. The blockchain may also be used to authenticate the borrower's identity, lowering the risk of fraud. Overall, the TO-BE claim process implemented with blockchain technology can improve efficiency, transparency, and security in the loan industry. The process can be more streamlined, with reduced administrative costs and improved customer experience.

Figure 6 shows the claim process within an insurance company where the blockchain technology is included. The workflow is the same in both the "AS-IS" and "TO-BE" insurance claim processes, but the "TO-BE" version improves efficiency, transparency, security, and traceability and reduces costs.

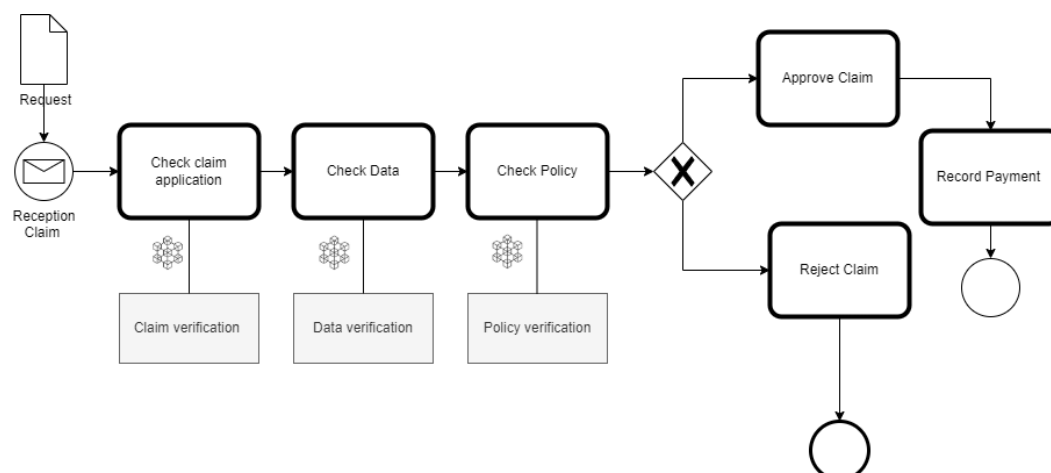


Figure 6. TO-BE insurance business process.

Claim processing can be automated based on specific rules and the availability of reliable data sources. When a claim is submitted, payouts to these insured consumers may be triggered. It can then be easily paid by accessing verified databases, and intelligent rules that can assist with any potential fraud predictions. The policies within an insurance company might be established as coded, decentralized smart contracts in which an individual agrees to pay the insurance business money in exchange for the guarantee of the company that it will cover that person's future expenditures. Depending on an insurance policy, blockchain smart contracts will generate immutable data that may instantaneously approve or reject any insurance claims submitted. In case the insurance refuses to cover a previously agreed condition, a smart contract will instantly dissolve. The process promotes mutual confidence between the customer and the insurance for these reasons: all data is disclosed clearly, and even the smallest contractual deviation leads to compensation to the affected party (Figure 7) [60]. Marlowe is a domain-specific programming language that is specifically designed for creating smart contracts on the blockchain. The domain-specialized functional language enables the development of smart contracts in the financial sector, including insurance. The language uses a visual interface that allows users to create smart contracts using pre-built templates, reducing the time and effort required for contract creation. Marlowe also offers significant advantages in terms of scalability and security. The language is designed to be scalable, which means that it can handle a large number of contracts simultaneously, making it suitable for use in the insurance and financial industries. Additionally, Marlowe offers robust security features, such as encryption and authentication, that help to protect smart contracts from unauthorized access and manipulation [61].

Marlowe can be used in a variety of ways within the insurance industry, including policy issuance, claims processing, and fraud detection. Smart contracts created using Marlowe can be used to automate the claims processing process, reducing the time and effort required for claims handling. These contracts can be designed to automatically process and verify claims, trigger payments, and update policyholder records based on predefined rules and conditions. Overall, Marlowe offers significant advantages for insurers looking to automate their processes, reduce administrative costs, and provide a more efficient and transparent service to their customers. By leveraging Marlowe for smart contract creation, insurers can improve the accuracy and security of their processes while reducing the time and effort required for policy issuance claims handling and fraud detection.

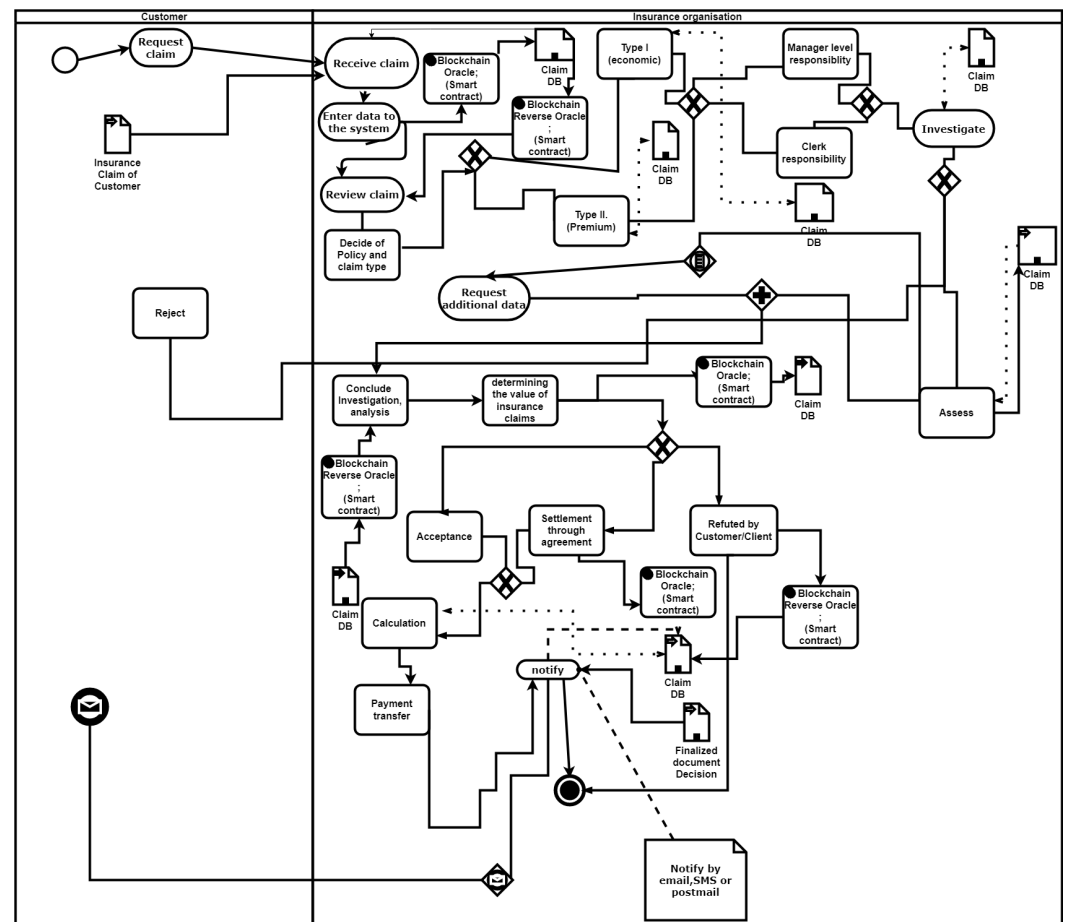


Figure 7. Insurance claim business process extended with blockchain patterns.

4.3. Loan BPM Implementation as a Web Service

The authors of [62] describe design patterns that can be applied in software and service architecture to incorporate blockchain technologies. In [63] there is a framework that can be used for the analysis of whether the targeted domain is appropriate for the application of blockchain technologies. In the banking environment, the emphasis was/is on payment transactions. However, other essential business processes are already automated entirely or partly in finance. Furthermore, these business processes use algorithms that are linked to a discipline called AI (artificial intelligence) succinctly. The complex activities are realized through web services in the style of service-oriented architecture; naturally, the services that occur could also be microservices. There are use cases and templates for business processes that are related to finance, and especially to the bank industry [53,64,65]. These models and templates of business processes make it possible that beyond the patterns of workflows, the patterns for application of blockchain technologies could be included in the generic models and the invocation of the function of blockchain technologies can be implemented through web services [66].

- **Conformance** examination aims to test whether the behavior of the instance of a process model is in line with the prescribed requirements for the single process model;
- **Compliance** investigation contains techniques to audit whether the regulation, rules, prescriptions, and constraints are satisfied in the instance of the business process;
- **XAI, explainable AI** The AI (ML, machine learning, D.Sc., data science) algorithms give the foundation for decision-making. In a business process, some humans play active roles and there are some who play passive roles or only monitor the results. The AI algorithm should provide information that is interpretable to humans. This interpretable information might have been created through specific activities that

might consist of web services invoking blockchain patterns, services that are a façade of AI algorithms, and conveying the basic information that can be translated into an interpretable format.

The blockchain patterns implemented as Web services should care for data quality, the volume of data, and data removability to keep in hand conformance with non-functional requirements and GDPR [67]. Software patterns are defined that can be used in a service-oriented architecture and business process models [62].

- **Oracle and reverse-oracle pattern** provides the communication channel between the closed blockchain environment and the execution of business process models;
- **Off-chain data storage** can be used since the representation of the instance of a business process and the documents that are involved in transactions may generate a volume of data that are hard to store in blocks and that are stored in external storage;
- **Contract patterns.** The smart contracts yield the tool and interface to describe the business rules that are realized in web services that are devoted to representing business entities and activities of business processes. The relevant smart contracts can interpret the business roles codified in web services.

4.4. Advantages and Challenges for Financial Companies in the Application of Blockchain Technology

In this section, we discuss open challenges and recommendations for the development of blockchain solutions for companies in the context of credit and claim requests (Figure 8). Some advantages for companies as reported by previous literature are as follows [3]:

- **Agility** gives companies the ability to assemble teams around such developments freely, which can include “smart contracts”, and allow the company to automatize business processes;
- **Actions** that were created in relation to past and current loan applications will be visible to all; e.g., new employees of companies can also see past actions on blockchain and act in line with previous decisions made, helping pass knowledge in the company;
- **Institutional memory:** that is, there are indelible extracts of all transactions and past actions of the company.

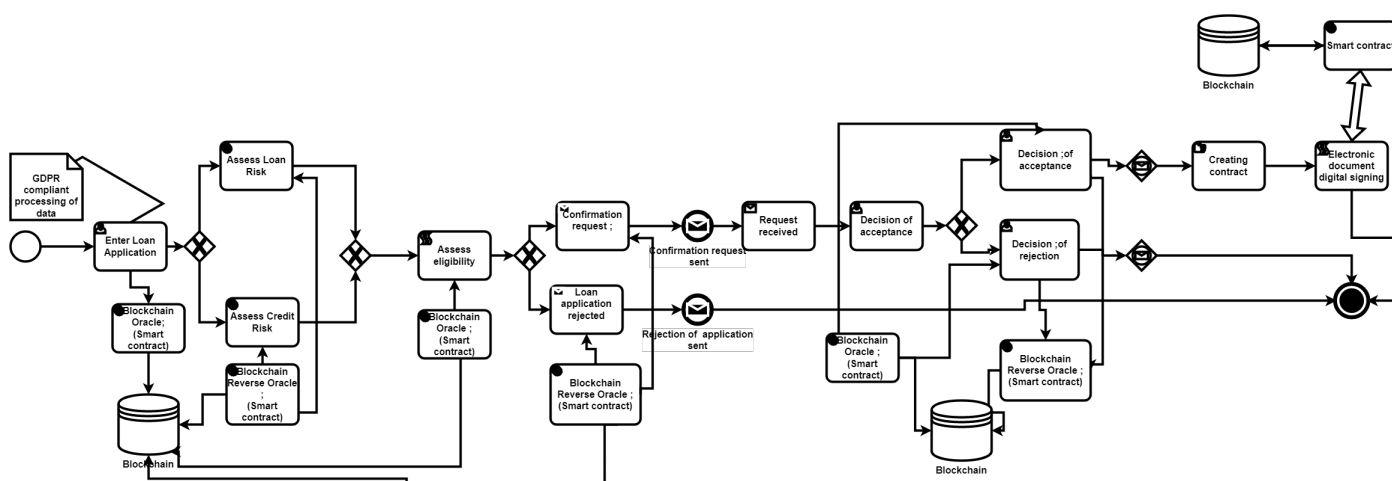


Figure 8. Loan application extended by blockchain patterns.

Financial companies’ business models will be disrupted as more and more block chains are put in place.

The primary challenge in this scenario is the absence of regulation and operating frameworks that have not been put in place, specifically regarding the use of blockchain technology in this domain. Although blockchain is often used in the financial world

for cryptocurrencies, applications of blockchain for optimizing and supporting financial operations are still on the rise, therefore, such regulation is still missing.

The second challenge is in terms of the maturity of the technology. According to previous literature, there are a number of open challenges related to scalability, interoperability, standardization, and energy consumption that may still need to be taken into account before implementing such a solution [68].

Another challenge comes from the cybersecurity standpoint. Although in the beginning it was claimed that block chains provide no point of failure, lately, blockchain attacks have been on the rise, such as in the example of the 51 percent attack [69]. Checks and prevention techniques are already ideated [70] for such attacks, yet in solutions such as loan applications, such defense mechanisms must be seriously analyzed and put in place obligatory.

Blockchain provides significant operational benefits, since current information systems rely on centralized databases, therefore contributing to the creation of silos and compartmentalized operations. Implementing a blockchain solution that is timestamped, immutable, and contains a unique version of the truth will help simplify audits as well (Figure 8).

GDPR and Related Legal Issues of Privacy

Companies face conflicting requirements in the case of the privacy of personal identifying information (PII), especially in finance. The legal and regulatory prescriptions make it necessary to collect personal data in a contractual relationship. If a permissioned or private blockchain system is applied in the financial enterprise, then the company (bank, insurance, and other financial institution) and its clerks should be considered data collectors according to GDPR [71]. In the blockchain architecture, the role of “miners” is necessary; their responsibility is to validate the “transactions”, thereby, the “miners” can be considered “processors”. In a permissioned or private blockchain architecture, a proper contractual relationship can be created according to the GDPR data-handling principles. The primary goal of the application of the blockchain is to provide an immutable software/data architecture for information logistics in a business process management and modeling context. The other properties of blockchain technology, e.g., transparency and non-repudiation in permissioned or private blockchain systems, appears advantageous, although in a public blockchain system it is dubious from the viewpoint of GDPR. The risks of the application of blockchain for document processing in finance are incorporated in the use of PII (personal identifier information) in the processing of documents with the assistance of blockchain. In the case of a permissioned or private blockchain, the risks can be mitigated by maintaining the data protection regulation. To keep the risks at a low level, a concerted action of information security architecture and smart contract activities are required [72–74]. A permissioned or private blockchain ecosystem may be operated by a single enterprise or association of companies in a specific market sector. Thereby, compliance with GDPR can be achieved through sophisticated access rights management in the company and the services of permissioned/private blockchain technology. We concentrate on business processes and the linked document and data-processing activities, but an outlook for data transfer out of the company, moreover, outside the EU, should be of concern. The permissioned blockchain has the capability to provide an adequate level of data governance even in these cases. In the context of the blockchain application, the rights of the data subjects should also be considered. The rights of data access and portability can be achieved. The technical realization of the rights to data eradication, correction, and the objection to processing is not obvious. The fulfillment of these requirements demands an investigation of the available solutions. The use of public blockchain means higher risks, so it requires more serious safeguards to ensure the protection of personal data. Using the blockchain patterns, the “clear text” is stored in external databases, off-blockchain; it is an issue that should be contemplated according to the content of the text, whether the clear text needed cryptographic protection or if it can be stored in this format. If the security risk analysis advises applying

the cryptographic solution to protect personal data even in documents stored off-chain, there are opportunities that can be selected, for example, “commitment” ([75], Chapter 24), keyed hash function ([76], Chapter 6), or another cryptographic scheme that guarantees high-level data protection to store the original clear text in the form of ciphertext [77,78]. The data on-chain should contain only the evidence that the data exist in the adequate form that fits the required level of data protection using the appropriate encryption technique. Recently, distributed database implementations have been developed based on distributed ledger technology that can be considered for use for the storage of large volumes of data in the context of blockchain technology and in enterprise architecture [79]. In the case of inter-organizational document flow, but even in internal document flow, the requirements of data protection and an audit trail are mandatory; moreover, that the decision-making should be tracked and be transparent is also compulsory because of the legal and regulatory rules [71,80,81]. During the process, the originality, validity, authenticity, and provenance of documents should be kept in hand. Either in a credit request or in an insurance claim, the issues that are raised are the following:

Requesting authentic documents. The financial institution (either bank, insurance company, or any other type) should access subject-specific authentic documents and information. In the case of a loan request, information should be collected about the requestor. In the recent FinTech framework, the financial institution may use credit bureaus. One of the credit bureaus can provide basic information about the requestor person, or the legal entity, to filter out potential customers with deceitful or unfavorable data. The other credit bureau can provide data that can be obtained from the banks that may have the requestor as a regular customer. Typical data that should be scored includes debt and loans of credit cards, performance of the payments, and how many bank accounts and credit/debit cards the potential customer may have. In recent cyberspace, data can be collected from telecommunication companies, retail chains, and utilities about invoice settlements. There are countries with central citizenship registration so that the existence of a person can be checked; in the case of companies, the company court serves as the validation of the existence of a firm. All interchange of data, electronic records, or documents can be based on blockchain technology to ensure the authenticity and validity of the communicated data. Although other technologies can be used, blockchain technology provides a seamless data interchange either in inter- or intra-organizational scenarios. In the case of an insurance claim, the customer’s data should be verified through retrieval from the database. Then, the insurance policy and the type should be checked after assessment of the damage assessment should be made. After the evaluation, a decision is made about disbursement, taking into account the claim and the actual damage. Blockchain technology and smart contracts can be employed for tracking documents, saving events and decisions, and furthermore controlling compliance to the various related regulations. The business rules for controlling whether the clerk who handles the customers’ data is authorized or the documents and data are authentic can be enforced and traced through smart contracts.

Transparency through tracking. People are interested in the usage of their data, and they like to control their access. The industrialized nations have laws and regulations in force that oblige the firms to conform [80–82]. Blockchain technology offers trustworthy, reliable, and immutable solutions for audit trails. Such audit trails make the work of auditors more conducive, grounded, and dependable.

Data protection of PII: The individuals who in either use case are concerned with sharing their data and want to give access only to those persons and institutions that are legally authorized. The usage of their PII is necessary for the actual business processes. Outside the business processes and authorized persons involved in the actual activities who should use the data, nobody else can access the data. Blockchain technology, smart contracts, web services, and controlled message-passing mechanisms can yield a solution that enforces and maintains compliance with the regulations [66].

Integrity rules. In the smart contracts, the integrity rules can be codified in an operational-way that complies with GDPR, the Data and AI Act, and the business rules of

the company [83–86]. Smart contracts can define business rules for both the inter- and intra-organizational relationships to enforce data and other governance rules automatically. In inter-organizational communication, those PIIs can be shared (only what is necessary for other organizations and conforming to the regulations of authorities that give and maintain permission for data handling). According to GDPR, the data can be gathered and retained only for the goals that are specified in the data handling policy. The policy and the related smart contracts should contain the following elements, however, the list is illustrative, non-complete, and not exhaustive: (a) information about the data-gathering methods and the utilization of PIIs, (b) constraints on the retention period of the collected data, (c) providing information to the new customers about the data privacy policy including the data handling, (d) the explicit goals of the data gathering, (e) how the security of data gathered is ensured, and (f) how the customers/consumers and the other users can obtain access rights to the gathered data and make use of it.

5. Contribution

This research concentrated on the application of the M2P paradigm in the context of business process modeling and operationalization, primarily [36]. The other issue that was investigated was how to use the patterns in business process modeling, firstly the workflow patterns [51], then patterns of service-oriented architecture [87], furthermore, the patterns of blockchain technology [62]. The UML activity diagram (AD) was selected instead of the full-blown BPMN 2.0 to make communication simpler with the project participants of the companies involved in the case studies [88,89]. A meta-model for AD was developed that made it possible for model-checking relational logical predicates to be formulated. The checking of the soundness of the model through the logical predicates is performed by the AD meta-model and Alloy [26,39].

Model: A meta-model for AD was developed that made it possible that model-checking relational logical predicates could be formulated. The checking of the soundness of the model through the logical predicates uses the AD meta-model and Alloy. A set of logical rules as a representation of model checking was elaborated. Using the meta-model and before-mentioned patterns, a method is defined for detecting the dubious or defective components of business problems.

Architecture: The facilities for the meta-modeling of YAWL were utilized for UML AD [90,91]. Acceleio is a plug-in for the Eclipse modeling framework that supports model-driven architecture [92–97]. Alloy supports relational logic for the model-checking of software systems [39,40]. Papyrus is a Java plug-in and a graphical editor that helps manipulate and transform diagrams, according to model-to-text (M2T) paradigms [98–100].

Method: We used the design science research and software case study research method to assess the results of the research work [47,48,101]. During the research work, we employed disciplined software-engineering methods in the form of object-oriented analysis and design. For program code generation, we exploited the above-mentioned toolset (Eclipse, Acceleio, and Papyrus). We utilized the capability of YAWL and Papyrus to define the meta-model and fit the meta-model to the purpose. To obtain the requirements for two case study-level experiments, we consulted the partners at companies with structured interviews.

Implementation: Acceleio and Papyrus were used for software model transformation. YAWL was applied to interpret the XML representation of business processes and the workflows; moreover, the meta-modeling and model-checking capability of YAWL was utilized for the workflows. The YAWL model-checking ability focuses on the structure of the workflows, so we inserted a step for model-checking other properties of the specified business processes, for example, the correct application of SOA and blockchain patterns.

We created a theoretical framework to integrate components to respond to timely research and business issues in the area of financial services technologies. We utilized contemporary technologies and the most recent development to build up a seamless integration of methods that have practical relevance as business process and workflow modeling, patterns of blockchain, SOA, and workflow, and furthermore, we used a method that has a

mathematical basis as relational logic (Alloy). We carried out two case studies to validate our approach and demonstrate that the design models can be transformed into an operational, executable format to reduce the burden of the design and implementation process in a rapidly changing business environment so that it makes it possible for enterprises to react in an agile way. The various model-checking steps provide the opportunity to reduce defects and enhance compliance with the rule of business and regulatory authorities.

6. Summary

Blockchain technology has gained significant attention in recent years, especially in the field of finance. Blockchain-based business process management (BPM) is one of the potential applications of this technology, which involves the use of blockchain to manage business processes in a transparent, secure, and efficient manner.

To facilitate the use of blockchain technology in BPM, we have created a structured UML profile which extends the UML meta-model by adding the blockchain patterns to the activity diagram. This profile can be used to adapt the UML meta-model for business process modeling in the finance sector.

In the case of loan applications, blockchain patterns can be used to manage the workflow efficiently. Private, permissioned blockchains can be utilized, where one instance of a workflow can be linked to a blockchain. There are patterns of blockchain activities that can be applied, such as Oracle and reverse-Oracle, for storing and retrieving data.

Smart contracts can be used to interface documents, enforcing syntactic and semantic rules on documents. The external database can be exploited to maintain the performance of the systems to avoid a heavy load on block generation, while personal and sensitive data can be protected through anonymization or pseudo-anonymization in the external database, thereby ensuring GDPR compliance. The retention of data according to the legal rules can be enforced through this external database, which serves as a single source of truth.

For the codification of contractual relationships, a legal and smart contract pair can be implemented, where a smart contract can realize a constrained set of requirements and make it executable. This formally “codified” knowledge can be automatically enforced, and regulatory compliance checking can be carried out automatically. However, limitations of the programming or script language restrict the semantic richness of smart contracts. The part of the legal contract that can be formulated in rules can be automated efficiently, while the analog parts that contain the long, legally binding, detailed requirements can be interpreted by humans and stored in the external database. Effective man-machine interaction is required if the automated interpretation of the analog part is required.

To balance privacy and transparency, a private, permissioned blockchain architecture can be utilized, where the data that needs to be accessed by the interested party can be visible to stakeholders. Sensitive data within blockchain and external databases should be encrypted according to GDPR and other legal and commercial regulations. Transparency is important because of the utilization of machine learning and data science methods in risk analysis, credit scoring, and other decision-making procedures.

At the organizational and company-level, service-oriented architecture can support the fulfillment of the service demands of activities within processes. Web services can be defined as utilizing web services and APIs to connect to technology architecture, such as blockchain services as operationalized patterns, database management systems, key management systems for cryptography, and natural-language processing for generating structures to create the “Analog and Digital parts” of contracts (smart contracts and legal contracts).

The application of blockchain technology can be perceived as web services or microservices that are called tasks of specific business processes. However, it is cumbersome and complex to maintain a key management system and ensure the secrecy of keys to realize satisfying cryptographic protection, and to maintain a background (legal) ontology that supports filling in both “Analog and Digital parts” of contracts and moreover to maintain a permissioned blockchain infrastructure (company or sector level).

The patterns of business processes and web services can extend and expand workflow patterns, which are elementary building blocks that can be either extended or expanded by necessary constituents to take into account the specialty of business processes in financial services technologies and the application of blockchain technologies.

To validate the extended diagram, namely the activity diagrams or BPMN diagrams, the whole extended diagram can be transformed using a relational logic-based approach, which can help ensure the correctness of the extended model.

In the future, blockchain integration in the banking and insurance field can be a promising multi-actor research area. Use cases can be collected from real-life scenarios with the support of the Central Bank. Modeling and investigating improvements from transparency, explainability, and effective uses of blockchain technology and AI provide opportunities for future research and application.

Future Work

There are several potential areas for future research in the integration of blockchain technology into business processes using UML profiles and model transformation. Some of these areas include:

Further exploration of use cases: While there have been some real-life use cases of blockchain technology in the banking and insurance industries, there is still a need for more comprehensive studies to understand the potential benefits and limitations of this technology. Further exploration of use cases can provide valuable insights into the effectiveness of the integration of blockchain technology and identify areas where it can be improved.

Investigation of different types of blockchain technology: currently, most studies on the integration of blockchain technology into business processes focus on public or private blockchains. However, there are several other types of blockchains, including hybrid and private blockchains, that may be more suitable for certain business processes. Investigating the effectiveness of different types of blockchain technology in different scenarios can provide a more comprehensive understanding of the technology's potential.

Optimization of algorithmic approaches: while algorithmic approaches can significantly improve the efficiency and effectiveness of the system, there is a need to optimize these approaches to ensure that they are scalable and can handle large amounts of data. Further research can explore different optimization techniques to make the system more efficient.

Evaluation of the effectiveness of human-machine interaction: While human-machine interaction is important in ensuring the effective adoption and use of blockchain technology, there is a need to evaluate the effectiveness of different interaction techniques. Further research can explore different approaches to human-machine interaction and evaluate their effectiveness in different scenarios.

Investigation of the impact on regulatory and legal frameworks: The integration of blockchain technology into business processes can have a significant impact on regulatory and legal frameworks. Further research can investigate the potential implications of this integration on existing frameworks and identify areas where changes may be needed.

Overall, these areas provide a starting point for future research on the integration of blockchain technology into business processes using UML profiles and model transformation. With continued research, it will be possible to optimize the integration of blockchain technology and enhance its effectiveness in different scenarios.

7. Conclusions

Agility is one of the strengths of the blockchain systems, as business processes can respond to different changes quickly. Blockchains enable the use of “smart contracts”, the automatic execution of activities according to conditions; thereby, such automated constructs of execution can improve the agility of the processes significantly.

At the same time, blockchain technology can simplify compliance checking, which allows sharing of confidential data securely. Financial companies in this manner can provide

access to data by regulatory agencies. The General Data Protection Regulation (GDPR) enforces serious constraints on financial companies and strict requirements and obligations on service providers who manage and process personal data. The use of blockchain also enables data owners to impose consent of data usage, which ensures that only specified and authorized parties (for instance, regulation authorities) can access and process personal data, and logs all data activities in an immutable distributed ledger using a smart contract that contains private data.

The most promoted use is in scenarios in which there is a need for transparency and security of records, where processes can be tracked in real time.

Many modern businesses and organizations have embraced the use of blockchain, as the decentralized process has resulted in a flexible and open environment which promotes collaboration and collective decision making [102,103], and revolutionizes the inter-operation among multiple parties in the financial industry [104].

An important outcome from implementing blockchain technology is also the increased level of trust. Trust is an important “asset” in the financial industry. The use of blockchains and blockchain innovations within financial companies can help them solve trust problems between different actors in the process. In this paper, we showed how blockchains improve the quality of the loan business process, as blockchain-based tracking of information can be beneficial for financial companies from different points of view. Previous research claims that the value created comes from exploring the opportunities this technology can enable in the business process rather than just replacing the technology in use [105], therefore this paper in this line of thought provides additional considerations for how such a process can be implemented, advantages and challenges for the financial companies implementing it, and reflections for BPM implementations. The pattern and business process descriptions provided in this paper can be a valuable first input for practitioners and can be used as a comprehensive starting point to be adjusted for the specific needs of the financial company, to be able to support the company properly. We suggest adjustments as from our past works [29,58,59]: we understood that such implementations are context-dependent, and therefore their suitability or revision will be needed in the company-specific context. Different stakeholders must be involved in the decision-making to estimate objectively the challenges and opportunities that may arise for the financial company. In addition, we believe the details provided in this paper can help the banks employ blockchain solutions for their loan operations and this paper can provide a wider perspective on the benefits, opportunities, and the challenges of the implementation of such solutions. In conclusion, the benefits of the use of blockchain technology in the financial industry become more apparent, and are considered as having significant importance for companies to improve business processes. The identified research challenges serve as a baseline for future implementation of such systems. Our next steps foresee work on the workflow rules’ construction for blockchain and business processes patterns, implementation of the sequence of workflow patterns, development of proof of concept, and conducting of software experiments.

In this paper, we showcased the processes of loan applications and insurance claims, and we proposed a business process pattern that companies can use and adapt. The example shows the critical role of blockchain in executing the process in banks and the insurance industry.

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Data Availability Statement: The data and code presented in this study are available on request from the authors.

Conflicts of Interest: The authors declare no conflict of interest.

Abbreviations

The following abbreviations are used in this manuscript:

Article specific

AD	UML Activity Diagram
M2T	Model-to-Text
M2P	Model-to-Program
SOA	Service Oriented Architecture
PII	Personal Identifying Information
IS	Information System
IT	Information Technology
IT/IS	Information Technology and Information System
ERP	Enterprise Resource-Planning System
ITIL	Information Technology Infrastructure Library
TOGAF	The Open Group Architecture Framework
XML	Extensible Markup Language
JSON	JavaScript Object Notation
DBMS	Database Management System
BPMN	Business Process modeling Notation standard version 2.0
DOM	Document Object Model

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